NASA TECHNICAL TRANSLATION NASA TT F-15,728

CARDIOPULMONARY EFFICIENCY IN FORMER AND ACTIVE CHAMPION SCULLERS*

F. Dorschner and A. A. Buehlmann

Translation of: "Kardiopulmonale Leistungsfaehigkeit ehemaliger und Aktiver Eliteruderer," In: Schweiz. med. Wschr., Vol. 130, pp. 501-508, 1973.

(NASA-TT-F-15728) CARDIOPULMONARY EFFICIENCY IN FORMER AND ACTIVE CHAMPION SCULLERS (Linguistic Systems, Inc., Cambridge, Mass.) 19 p HC $3.25 CSCL 06P G3/52
N75-11616
Unclas 02840

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 NOVEMBER 1974

STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TT F-15728		
4. Title and Subtitle Cardiopulmonary Efficiency in Former and Active Champion Scullers		5. Report Date November, 1974 6. Performing Organization Code
7. Author(s) F. Dorschner and A. A. Buehlmann		8. Performing Organization Report No. 10. Work Unit No.
9. Performing Organization Name and Address LINGUISTIC SYSTEMS, INC. 116 AUSTIN STREET CAMBRIDGE, MASSACHUSETTS 02139		11. Contract or Grant No. NASW-2482 13. Type of Report & Period Covered TRANSLATION
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of: "Kardiopulmonale Leistungsfaehigkeit ehemaliger und Aktiver Eliteruderer," In: Schweiz. Med. Wschr., Vol. 130, pp. 501-508, 1973.

16. Abstract

Cardiopulmonary efficiency was determined in 12 active and 12 former championship scullers grouped according to age. The results are compared. None of the older subjects had any severe systemic diseases, especially of the lungs or the heart. Circulating blood volume, hemoglobin concentration, hematocrit, arterial blood pressure, alveolo-arterial Po2 gradient, arterial blood gases and lactate concentration were determined at rest, during submaximal work load on a bicycle ergometer and again after recovery. Total and vital capacities were higher than the predicted values, i.e., the residual volume increases with age. Resting blood pressure, resting blood gases, hemoglobin, hematocrit and the other above-mentioned, simultaneously performed determinations yielded largely normal results. The 12 active athletes have a significantly higher working capacity (method of Sjoestrand) and blood volume than the former champions. In relation to

17. Key Words (Selected by Author(s))	18. Distribution Statement
	UNCLASSIFIED - UNLIMITED

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

the normal population the cardiopulmonary efficiency of the formerly active group is remarkably higher as a result of continual cardiovascular training after retiring from the active sport.

CARDIOPULMONARY EFFICIENCY IN FORMER AND ACTIVE CHAMPIONSHIP SCULLERS*

F. Dorschner and A. A. Buehlmann

In conjunction with the summer Olympics held in Mexico City in /502
1968, we studied some of the members of the Swiss rowing team to determine the relationship between heavy physical work, hypoxia, hyperventilation and hypovolemia [3]. The subject of the present paper is a determination of how athletic high-performance training over a long period of time affects cardiopulmonary adaptation in advanced age. We therefore studied an additional three groups of former champion scullers, almost all of whom belonged to the national team in their time, aged 40, 50 and 60 years on the average.

As far as rowing as a competitive sport is concerned, the distance covered (2000 meters) and the average time of 6.5 minutes satisfies the prerequisites for physical performance limited by cardiopulmonary capacity and constitutes a type of training which has a considerable influence upon the circulation, with at least 1/6 of the total skeletal musculature being involved with a load intensity of more than 50% of the maximum circulatory capcity for 3-4 minutes [10]. Our studies are based primarily upon the measurements of the lung volume and respiratory reserve, circulating blood volume, work capacity according to Sjoestrand [13], blood pressure, hemoglobin, hematocrit, total protein, lactic acid, arterial blood gas and alveolo-arterial P_{O_2} gradient at rest, during submaximal stress in a relative steady state and following recovery. In addition, a resting EKG and a chest X-ray were taken, as well as a brief general physical examination.

---

*Lecture delivered at the Thirty-first Advanced Course in Vocational Training of the Swiss Society for Internal Medicine, March 2-3, 1972, Luzerne.

Subjects

The subjects were three groups of former champion scullers whose statistics are shown in Table 1 together with those of the previously described group of still active rowers [3]. Of all the members of the former national team, all 12 in Group I, 10 out of 14 in Group II, 8 out of 17 in Group III and 7 out of 16 in Group IV were studied. The athletic activity required for high-performance training necessitated a physical activity of at least 90 minutes each week, with considerable effects on the circulation, in which the pulse rate was necessarily more than 120 per minute on several occasions. Those who had consumed more than ten cigarettes daily for at least five years were considered smokers.

TABLE 1. VALUES WITH STANDARD DEVIATIONS FOR THE DIFFERENT AGE GROUPS OF ACTIVE AND FORMER CHAMPION SCULLERS

Group	No.		Age (years)	Height (cm)	Weight (km)	Years Following training	Duration of training (yrs)	Present athletic activity*	Wt. gain (kg)	Nicotine consumption *
I	12	$\bar{x}$	24.8	185.0	83.2	-	-	active	-	-
		±SD	3.7	4.7	7.4					
II	10	$\bar{x}$	39.9	180.3	83.2	10.2	10.7	9/10	4.8	1/10
		±SD	1.4	5.4	4.8	2.3	2.0		3.1	
III	8	$\bar{x}$	48.6	187.6	87.5	19.0	9.9	8/8	4.1	-
		±SD	3.3	4.8	7.4	3.7	2.8		6.3	
IV	7	$\bar{x}$	60.1	185.1	89.1	29.4	9.4	5/7	5.8	4/7
		±SD	3.9	6.4	10.6	4.4	5.1		6.4	

* For definition see the text.

Method

The lung volume and respiratory reserve were determined spirometrically (helium dilution method, using the Godart "Pulmotest" spirometer). By means of a Cournand cannula inserted in the brachial artery and a Statham electromanometer, the diastolic and systolic blood pressure were measured, as well as the mean arterial pressure and the pulse rate; the cannula was also used to collect blood for determining arterial blood gas, hemoglobin, hetamocrit, total proteins, circulating blood volume (Cr^{51} method) as well as lactic acid at rest, following submaximal stress lasting 10 minutes and following 15 minutes recovery (Group I after 30 minutes). In order to achieve a sufficiently high pulse rate of more than 150/min in the steady state in this stress, required for determining the working capacity (WC_{170} according to Sjoestrand and WC_{160} for Groups III and IV), all of the subjects spent a five-minute orientation period 30-60 minutes prior to the start of the actual test on a bicycle ergometer (according to Fleisch), with only the pulse rate being checked. Measurement of hemoglobin concentration and oxygen saturation in the arterial blood was accomplished with a IL CO-Oxymeter, while the arterial P_{O_2}, P_{CO_2} and pH were determined with a IL gas analyzer. Standard bicarbonate was determined nomographically. The alveolo-arterial P_{O_2} gradient was determined in the usual fashion using arterial P_{CO_2} and the respiratory quotient. For the lactate determinations, the blood samples were deproteinized immediately following collection. /503

RESULTS

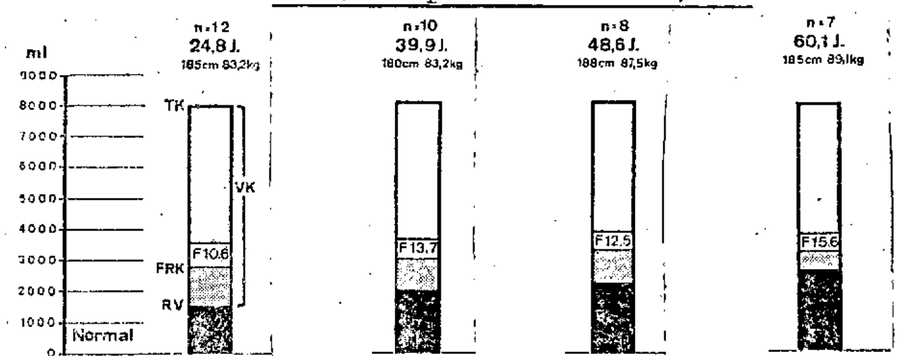
1. Resting Values

a) Lung volume, respiratory reserve and respiratory economy.

Figure 1 and Table 2 give some idea of lung volume, respiratory reserve and respiratory economy of the various age groups. The measured values for total capacity (TC) and vital capacity (VC) in the case of Group I and II are approximately 10-25 times above the ideal values given by Miller [11], but on the average correspond precisely to the ideal values set by the European Coal and Steel Community (cited in Ulmer [15]) as well as the values recently given by Amrein [1], while Groups III and IV on the average could not quite reach these latter values. The relative second capacity (SC) was normal on the average and decreased slightly with age, while the functional residual capacity (FRC) and the residual volume (RV) increased slightly with age.

b) <u>Arterial blood gas, alveolo-arterial P_{O_2} gradient, pH, hemoglobin, hematocrit and total protein (Tables 3 and 5)</u>. The resting values for the arterial blood gas (Figure 1), hemoglobin, hematocrit and total protein largely correspond to standard values. Only in Group IV, as a result of the age-related enlargement of the residual volume, was the mixing of the air somewhat poorer, so that the arterial P_{O_2} as well as the arterial oxygen saturation were somewhat reduced on the average. The alveolo-arterial P_{O} -gradient and the dead space quotient (VD/VT) were definitely increased in this group.

High-Performance Athletes
(Champion Scullers)



SC, %	75	82		77		77		69	
AGW, %	100	115		114		112		100	
VD/VT	0.35	0.35	240 W	0.36	263 W	0.37	240 W	0.39	201 Watt
O_2 sat. %	96.0	96.2	95.4	96.1	94.3	95.9	94.8	94.2	95.3
P_{CO_2}, mmHg	38.0	39.9	38.5	34.7	26.3	36.8	25.7	33.1	26.4
BV ml/kg	67	77.3		71.5		70.1		70.7	

Figure 1. Average Values for Lung Volume, Respiratory Reserve, Arterial Blood Gases and Circulating Blood Volume at Rest.

TABLE 2. AVERAGE VALUES WITH STANDARD DEVIATIONS FOR LUNG VOLUME, RELATIVE SECOND CAPACITY (SC), SPECIFIC VENTILATION AND DEAD SPACE QUOTIENT (VD/VT) AT REST

Group	n		TC (ml)	VC (ml)	FRC (ml)	Rel. SC (% of VC)	Specific Ventilation (ml/ml)	VD/VT
I	12	$\bar{x}$	7988	6479	2782	82	27.3	0.35
		±SD	897	580	528	6.0	3.3	0.07
II	10	$\bar{x}$	8070	6085	3100	77	32.1	0.36
		±SD	1032	729	769	6.0	2.4	0.06
III	8	$\bar{x}$	8344	6081	3356	77	30.3	0.37
		±SD	571	506	369	3.0	5.4	0.09
IV	7	$\bar{x}$	7986	5486	3214	69	37.9	0.39
		±SD	1083	935	491	7.0	4.1	0.09

TABLE 3. AVERAGE VALUES WITH STANDARD DEVIATION OF HEMOGLOBIN (Hb), HEMATOCRIT (Hct) AND TOTAL PROTEIN IN THE ARTERIAL BLOOD AT REST AS WELL AS FOR CIRCULATING BLOOD VOLUME AT REST (ml/kg of body weight).

Group	n		Hb (g%)	Hct (g%)	Total Protein (g%)	Blood Volume (ml/kg)
I	12	x	14.6	44.4	7.1	77.3
		±SD	0.5	2.2	0.60	2.2
II	10	x	14.8	44.3	6.7	71.5
		±SD	0.9	3.7	0.30	6.3
III	8	x	14.1	42.5	6.9	70.1
		±SD	1.1	3.3	0.56	3.9
IV	7	x	14.4	44.7	6.7	70.7
		±SD	0.2	2.1	0.33	5.2

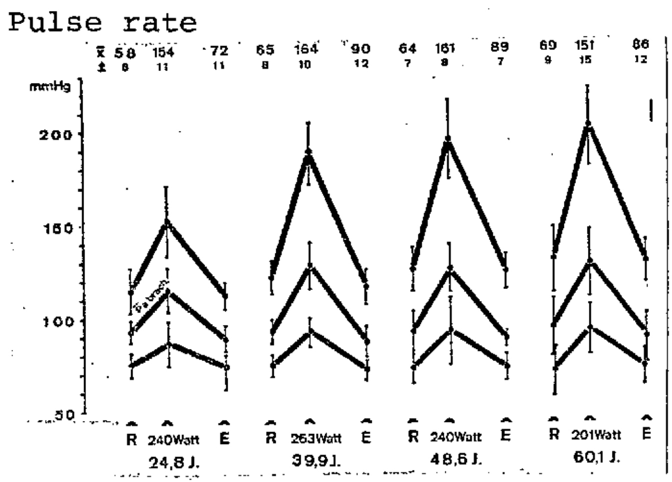
c) Resting pulse, resting blood pressure and circulating blood volume. The resting pulse (measured after 15 minutes lying at rest) was reduced in the active champions as anticipated, and increased slightly with advancing age (Table 4). The systolic blood pressure values also increased slightly with age, while the diastolic values dropped off somewhat and the blood pressure amplitudes were much greater. In no case did the former scullers exhibit hypertonia. In Group I, the blood volume was markedly increased with a body weight of 77.3 ml/kg, but in Groups II-IV was still above the normal value of 67.2 ± 4.6 ml/kg of body weight as ascertained by the same method in the same laboratory (Table 3).

2. Stress Values

The following criteria were used for evaluating cardiopulmonary efficiency:

- working pulse, working blood pressure and amplitude,
- arterial oxygen saturation, arterial P_{O_2} and alveolo-arterial P_{O_2} gradient,
- P_{CO_2}, standard bicarbonate, pH and lactic acid level in the arterial serum,
- AC_{170} according to Sjoestrand.

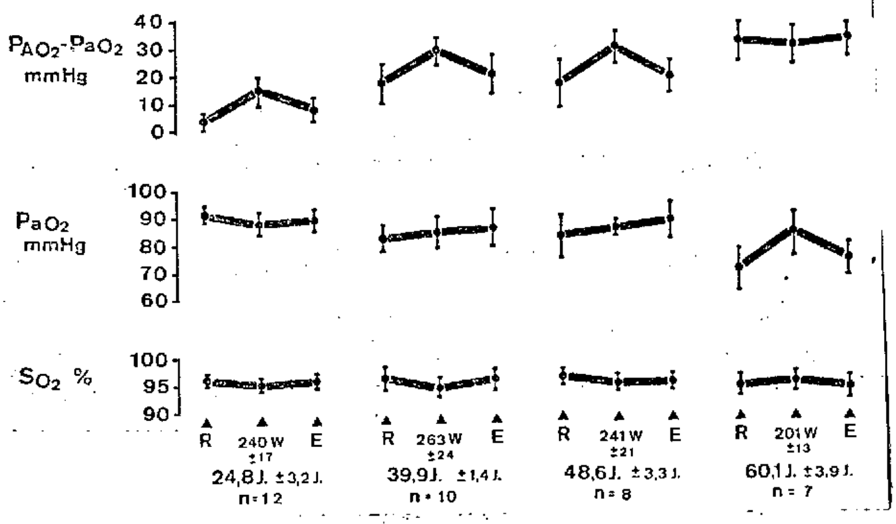
a) Working pulse, working blood pressure and amplitude. The active and former scullers in Groups II and III were subjected to an average load of 240-260 watts, while the 60-year-olds in Group IV were given an average of 200 watts, which facilitated comparison of the measured values. In Figure 2 and Table 4, the behavior of the pulse frequencies, systolic and diastolic blood pressure, blood pressure amplitude and mean arterial pressure at rest, at the end of the second stress session and after 15 minutes of recovery (Group I -- 30 minutes) are shown. During the stress, which differed only slightly with respect to pulse rate, the systolic blood pressure level rose in Groups II-IV, to a degree which increased with age and was markedly greater than in Group I. The diastolic values in Groups II-IV increased only slightly, likewise showing an increase with age, than in Group I, while the blood /504 pressure level increased sharply. Likewise the mean arterial pressure is much greater than in Group I. Following 15 minutes recovery, all the values fell below the resting values, later returning to the latter.



R = Rest J = Years
E = Recovery

Figure 2. Average Values with Standard Deviations for the Systolic and Diastolic Blood Pressure, Mean Arterial Pressure and Pulse Rate at Rest, After 10 Minutes Working Time and After 15 Minutes Recovery.

b) <u>Arterial oxygen saturation, arterial P_{O_2} and alveolo-arterial P_{O_2} gradient</u>. During stress, the average oxygen satura- /505
tion in Group I-II drops slightly below the resting value, while the 60-year-olds, subjected to a load approximately 50 watts less, show almost the same pulse rate due to the improved mixing of air; they also show an increase in arterial oxygen saturation with respect to the resting value (Figure 3, Table 5). The alveolo-arterial P_{O_2} gradient increases sharply in Group I-III, while Group IV shows a slight decrease with an increased resting value; this pattern is explained by an age-related deterioration of air



R = Rest J = Years
E = Recovery

Figure 3. Average Values with Standard Deviations for Alveolo-Arterial P_{O_2} Gradients, Arterial P_{O_2} and Arterial P_{O_2} and Arterial Oxygen Saturation at Rest, Following 10 Minutes Work and after 15 Minutes Recovery.

mixing at rest. All recovery values largely correspond to the resting values.

c) <u>P_{CO_2}, pH, standard bicarbonate and lactic acid level in the</u> /506
<u>arterial blood</u>. Under stress, the arterial P_{CO_2} in Groups II-IV drops off markedly as the result of hyperventilation, in contrast to Group I (Figure 4, Table 6). This hyperventilation also involves a more pronounced lactic acid acidosis, while the lactic acid level in the arterial serum for Groups II-IV, with the same wattage, increases to 2.5-3 times for Group I. Following recovery, the former scullers continued to exhibit a mild respiratorially compensated lactic acid acidosis.

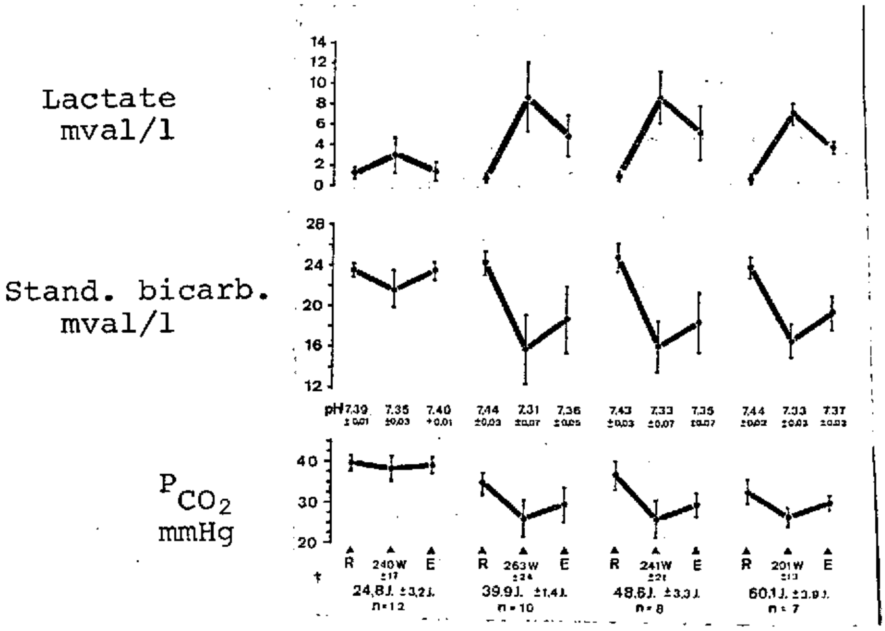
d) <u>Working capacity according to Sjoestrand</u>. The working capacity at a pulse rate of 170 beats/minute (AC_{170} according to Sjoestrand or AC_{160} for Groups III and IV) was extrapolated or

TABLE 4. AVERAGE VALUES WITH STANDARD DEVIATIONS FOR PULSE RATE, SYSTOLIC AND DIASTOLIC BLOOD PRESSURE, BLOOD PRESSURE AMPLITUDE AND MEAN ARTERIAL PRESSURE AT REST, AFTER 10 MINUTES OF WORK (AV) AND AFTER 15 MINUTES RECOVERY.

	n		Beats/ min.	Systolic BP (mmHg)	Diastolic BP (mmHg)	BP Ampi- tude (mmHg)	Mean Arterial BP (mmHg)
Group I	12						
At rest		$\bar{x}$	58	115.0	75.0	40	93
		±SD	6	12.0	6.7	9	6
AV, 240 watts		$\bar{x}$	154	153.0	86.5	67	116
±17 watts		±SD	11	19.0	11.7	16	12
Recovery		$\bar{x}$	72	111.0	74.0	37	89
(30 minutes)		±SD	11	7.4	8.4	7	8
Group II	10						
At rest		$\bar{x}$	65	121.0	74.0	47	92
		±SD	8	9.0	5.7	9	6
AV, 263 watts		$\bar{x}$	164	188.0	91.5	98	129
±24 watts		±SD	10	15.6	7.5	11	13
Recovery		$\bar{x}$	90	116.0	71.0	45	87
		±SD	12	9.1	5.3	9	8
Group III	8						
At rest		$\bar{x}$	64	126.0	71.0	55	91
		±SD	7	11.6	8.3	8	12
AV, 240 watts		$\bar{x}$	161	195.0	91.0	104	125
±21 watts		±SD	8	21.0	18.0	30	13
Recovery		$\bar{x}$	89	124.0	73.0	53	88
		±SD	7	9.0	7.3	11	4
Group IV	7						
At rest		$\bar{x}$	69	130.0	70.0	60	94
		±SD	9	18.0	13.0	10	15
AV, 201 watts		$\bar{x}$	151	202.0	92.0	110	128
±13 watts		±SD	15	21.0	13.5	14	18
Recovery		$\bar{x}$	86	119.0	72.0	47	88
		±SD	12	11.0	9.5	17	13

TABLE 5. AVERAGE VALUES WITH STANDARD DEVIATIONS FOR ARTERIAL OXYGEN SATURATION, ARTERIAL P_{O_2} AND ALVEOLO-ARTERIAL P_{O_2} GRADIENTS AT REST, AFTER 10 MINUTES OF WORK (AV) AND AFTER 15 MINUTES RECOVERY.

	n		O_2 Saturation (%)	P_{O_2} (mmHg)	$P_{AO_2}-P_{aO_2}$ (mmHg)
Group I	12				
At rest		$\bar{x}$	96.2	92.0	4
		±SD	0.7	3.0	3
AV, 240 watts		$\bar{x}$	95.4	88.0	15
±17 watts		±SD	1.0	4.0	5
Recovery		$\bar{x}$	95.9	88.0	8
(30 minutes)		±SD	0.7	4.0	4
Group II	10				
At rest		$\bar{x}$	96.1	81.7	17
		±SD	2.2	6.5	7
AV, 263 watts		$\bar{x}$	94.3	85.2	29
±24 watts		±SD	1.8	6.1	5
Recovery		$\bar{x}$	95.6	86.3	20
		±SD	1.9	7.0	7
Group III	8				
At rest		$\bar{x}$	95.9	81.4	16
		±SD	1.3	7.7	8
AV, 240 watts		$\bar{x}$	94.8	84.5	30
±21 watts		±SD	1.5	3.3	6
Recovery		$\bar{x}$	95.2	88.1	19
		±SD	1.6	6.6	6
Group IV	7				
At rest		$\bar{x}$	94.2	69.6	31
		±SD	1.9	8.0	7
AV, 201 watts		$\bar{x}$	95.3	82.8	30
±13 watts		±SD	1.3	8.5	7
Recovery		$\bar{x}$	94.1	72.8	32
		±SD	1.7	6.4	6



R = rest
E = recovery

Figure 4. Average Values With Standard Deviations for Lactic Acid Concentration in Arterial Serum, Standard Bicarbonate, Arterial P_{CO_2} and pH At Rest, After 10 Minutes Work and After 15 Minutes Recovery.

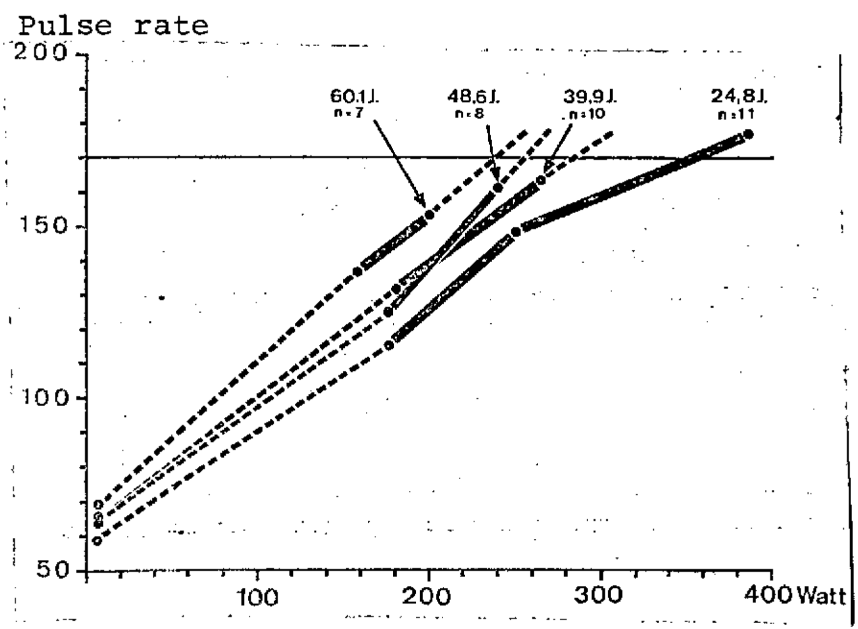


Figure 5. Average Values for Pulse Rate at Rest and At the End of Two or Three Stress Levels. Active scullers (24.8 yr) studied during the rowing season.

interpolated from the measured pulse rates from the two to three stress levels. In the case of the active champion scullers, this test was not performed during the time before the season in contrast to the previously discussed findings, but during the period of highest performance in the regatta season with an additional third stress level (Figure 5, Table 7). In the active champions the AC_{160} was nearly doubled in comparison with the conventional standard values in our laboratory [4], with 385 watts, corresponding to 178.8% increase. The 40-year-old former champions, with 280 watts were 148% over normal, the 50-year-olds with 257 watts 135% and the 60-year-olds with 215 watts 132% over normal.

DISCUSSION

The present study involved approximately 63% of the members of the Swiss national rowing team since 1936, i.e., 57 out of 59 former and active champion scullers. Of the 25 former champions (Groups II-IV), 22 were still performing training exercises with a beneficial effect upon the circulation even after giving up high-performance sport. Among the active scullers, and the 40-year-old and 50-year-old former champions, it was exceptional to find smokers, while among the 60-year-olds 57% of those studied smoked more than ten cigarettes per day. The weight increase after giving up /507 high-performance sport was an average of 5 kg and remained within strict limits (see Table 1). In the general physical examination we found no pathological findings of any significance in any case, especially not in the organs of the chest. The heart, examined by fluoroscopy and chest X-rays, never showed abnormal enlargement; in four cases there was a pronounced sinistral configuration, but no hypertonia was found. In the resting EKG the active scullers showed no pathological changes while the former champions in two cases showed isolated cases of venticular extrasystole, in three cases pronounced sinistrocardia and in one case a first-degree AV block. There were no coronary symptoms. One 60-year-old sculler had an EKG showing discrete signs of a scar caused by an infarct of the posterior wall with completely latent anamnesis. Six months after the study, one 40-year-old in Group II suffered from an infarct of the anterior wall, but remained practically ambulatory; it was only on the fifth day following sensations of pain that the diagnosis was made on the basis of a pathological EKG taken because of a moderately manifested stress dyspneia. The diagnosis was confirmed and therapy begun. As a result, the course of the illness was completely free of complications. In two instances, there was a situation involving series fractures of the ribs, and another with hematopneumothorax with formation of callosites. The blood morphological, blood chemical and urine tests showed normal findings in all cases.

In all age classes, the study of the pulmonary function indicated a large lung volume in the upper normal range, a residual volume increasing with age and a deterioration of air mixing. In general, the arterial blood gas, hemoglobin concentration and hematocrit were normal. The circulating blood volumes were still markedly increased in the scullers who were still active and to a lesser degree in those who were no longer active. The resting blood pressure levels corresponded to those of non-athletes and showed a marked increase in blood pressure amplitude with increasing age.

The cardiopulmonary adaptability to physical labor in the former champion scullers investigated, even 10, 20, and 30 years after giving up high-performance sports, was markedly above normal. The physical efficiency that decreased with age was paralleled by a low level of training. A measure of physical efficiency that was a function of training and was limited by cardiopulmonary characteristics was the markedly increasing pulse rate in the former rowers which increased more markedly under similar stress. The markedly higher systolic working blood pressure in comparison with those

TABLE 6. AVERAGE VALUES WITH STANDARD DEVIATIONS FOR ARTERIAL P_{CO_2}, pH, STANDARD BICARBONATE AND LACTIC ACID CONCENTRATION IN THE ARTERIAL SERUM AT REST, AFTER 10 MINUTES WORK (AC) AND AFTER 15 MINUTES RECOVERY.

	n		P_{CO_2} (mm Hg)	pH	St. bic. (mval/1)	Lactate (mval/1)*
Group I	12					
At rest		$\bar{x}$	39.9	7.39	23.5	1.14
		±SD	2.1	0.01	0.6	0.40
AV, 240 watts		$\bar{x}$	38.5	7.35	21.6	3.24
±17 watts		±SD	3.0	0.03	1.8	1.68
Recovery		$\bar{x}$	39.0	7.40	23.7	-
(30 minutes)		±SD	1.9	0.01	0.8	-
Group II	10					
At rest		$\bar{x}$	34.7	7.44	24.4	0.95
		±SD	2.7	0.03	1.1	0.26
AV, 263 watts		$\bar{x}$	26.3	7.31	15.9	8.86
±24 watts		±SD	4.6	0.07	3.4	3.30
Recovery		$\bar{x}$	29.8	7.36	18.9	5.14
		±SD	4.2	0.05	3.3	2.06
Group III	8					
At rest		$\bar{x}$	36.8	7.43	24.8	1.03
		±SD	3.3	0.03	1.4	0.26
AV, 240 watts		$\bar{x}$	25.7	7.33	16.2	9.00
±21 watts		±SD	4.3	0.07	2.5	2.52
Recovery		$\bar{x}$	29.7	7.35	18.6	5.60
		±SD	3.0	0.07	3.0	2.61
Group IV	7					
At rest		$\bar{x}$	33.1	7.44	24.1	0.93
		±SD	3.0	0.02	1.0	0.32
AV, 201 watts		$\bar{x}$	26.4	7.33	16.8	7.32
±13 watts		±SD	2.2	0.03	1.7	1.00
Recovery		$\bar{x}$	30.2	7.37	19.6	4.03
		±SD	1.9	0.03	1.7	0.62

* 1 mg% = 0.111 mval/1

TABLE 7. AVERAGE VALUES WITH STANDARD DEVIATIONS FOR PULSE RATE AT REST AND AT THE END OF THE SECOND OR THIRD STRESS LEVEL. IDEAL AND ACTUAL VALUES FOR WORKING CAPACITY AT A PULSE RATE OF 170/min (AC_{170} ACCORDING TO SJOESTRAND) OR 160/min WITH STANDARD DEVIATIONS.

Group	n		Resting Pulse/ min	Stress stage 1 watts	Stress stage 1 pulse	Stress stage 2 watts	Stress stage 2 pulse	Stress stage 3 watts	Stress stage 3 pulse	AC ideal (W)	AC act (W)
I	12	$\bar{x}$	58	178	115	240	154	384	176	206	358
		±SD	6	4	9	17	11	30	6	8	38
II	10	$\bar{x}$	65	180	132	263	164	-	-	188	280
		±SD	8	-	14	24	10	-	-	15	30
III	8	$\bar{x}$	64	175	127	241	161	-	-	190	257*
		±SD	7	12	13	21	8	-	-	11	33
IV	7	$\bar{x}$	69	157	137	201	154	-	-	163	215*
		±SD	9	13	21	13	13	-	-	14	14

* With a pulse rate of 160/minute.

scullers who were still active, in accordance with the results obtained by Drews [6] appears to be a function of age and not training. In contrast to Drews, however, we found a blood pressure amplitude during work which increased with age. With comparable performance, the lactic acid level in the arterial serum rose by a factor of 2.5-3 with respect to the active scullers, an expression of additional peripheral factors which limit performance, such as Strándell [14] reported on the basis of his studies of 140 healthy men. He found a close correlation between working capacity and lactic acid level and no significant relationship between cardiovascular data, lung volume and lung function. The loss of performance, related to age, which was observed in the former scullers after ten years amounts to 9-15%, a value somewhat higher than that given by Boettiger [2] on the basis of comparisons made with about 8000 participants in the Wasa long distance ski race involving a loss by 7% in ten years.

The important results of these studies include cardiopulmonary performance almost twice normal for the still-active champion rowers as well as an adaptability to physical work on the part of the former champion scullers that was still far above normal. The extent to which this increased adaptability and lung volume are influenced at the upper level of normal by the constitution of the individual or by the definitively abandoned high-performance training cannot be ascertained precisely. Saltin [12] found in a group of 29 former champion runners who had not had any athletic training for more than ten years, a maximum oxygen uptake that was 20% higher than normal and which he could not interpret precisely. The principal cause for the cardiopulmonary efficiency, which was always definitely above normal, seen in the former champion rowers investigated is definitely to be found in the present way of life, with more than average physical activity, as reported by other authors as well [5, 9].

Due to the small number of those investigated, the present paper does not allow any statements to be made regarding the risk of infarct. However, the complication-free course of illness of the infarct patient mentioned above merely confirms the view that the prognosis of a possible infarct is considerably improved by an improved information of collaterals or capillarization of the myocardium by physical training [7, 8].

REFERENCES

1. Amrein, R., Keller, R., Joos, H., and Herzog, H.: "New Standard Values for Pulmonary Function Testing with Whole-Body Plethysmography." Dtsch. med. Wschr., Vol. 94, p. 1785, 1969.

2. Boettiger, L. E.: "Physical Working Capacity and Age." Acta med. scand., Vol. 190, p. 359, 1971.

3. Buehlmann, A. A., Spiegel, M. and Straub, P. W.: "Hyperventilation and Hypovolemia in Sport at Moderate Altitudes." Schweiz. med. Wschr., Vol. 99, p. 1186, 1969.

4. Buehlmann, A. A. and Rossier, P. H.: Klinische Pathophysiologie der Atmung. (Clinical Pathophysiology of Respiration). Springer-Verlag, Berlin/Heidelberg/New York, 1970.

5. Clasing, D., Klaus, E. J., Durusoy, F. P. and Niemann, W.: "Spiroergometric Performance Tests on Old Gymnasts More than 50 Years of Age." Sportarzt, Vol. 17, p. 357, 1966.

6. Drews, A.: "Blood Pressure and Pulse Rate in Younger and Older Athletes During Bicycle Erogmeter Testing with Loads Increasing by the Minute." Sportarzt, Vol. 16, pp. 368-374, 417-420, 1965. /508

7. Eckstein, R. W.: "Effect of Exercise and Coronary Artery Narrowing on Coronary Collateral Circulation." Circulat. Res., Vol. 5, p. 230, 1967.

8. Fox. S. M. and Paul, O.: "Physical Activity and Coronary Heart Disease." Amer. J. Cardiol., Vol. 25, p. 298, 1969.

9. Grimby, G., and Saltin, B.: "Physiological Analysis of Physically Well-Trained Middle-Aged and Old Athletes." Acta med. scand., Vol. 179, p. 513, 1966.

10. Hollmann, W., and Heck, H.: "Cardiac Performance and Athletics." Aerztl. Fortbild., Vol. 19, p. 62, 1971.

11. Miller, W. F., Johnson, R. C., Jr., and Wu, Nancy: "Relationship Between Fast Vital Capacity and Various Timed Expiratory Capacities." J. appl. Physiol., Vol. 14, p. 157, 1959.

12. Saltin, B. and Grimby, G.: "Physiological Analysis of Middle-Aged and Old Former Athletes." Circulation, Vol. 38, p. 1104, 1968.

13. Sjoestrand, T.: "Functional Capacity and Exercise Tolerance in Patients with Impaired Cardiovascular Function." In: Gordon (editor): Clinical Cardiopulmonary Physiology, p. 201, Grune & Stratton Inc., New York, 1960.

14. Strandell, T.: "Circulatory Studies on Healthy Old Men." Acta med. scand., Suppl. 414, 1969.

15. Ulmer, W. T., Reichel, G. and Nolte, D.: Die Lungenfunktion, (Pulmonary Function), Georg Thieme Verlag, Stuttgart, 1970.